# 1.0.0 Purpose

This document seeks to provide options for persistent storage on a variety of container platforms. In addition, the solutions were benchmarked to get an idea of the performance that could be delivered.

## 1.1.0 Approaches

It quickly became clear that there were 3 primary approaches to delivering a persistent storage solution.

## 1.1.1 Attached Disk

The idea here is to create disks of some kind and then attach each of them to a node in the cluster.

The advantages of this approach are:

* Premium Storage can be used to achieve lower latency, higher throughput, and more IOPS.

The disadvantages of this approach are:

* The disk cannot be mounted to more than one node, all containers that use a specific volume must be on the same node.
* The configuration tends to be more complex because each node may need a driver and be mapped in some way to a specific volume.

Keep in mind that while this does offer much better performance, all disk activity is still encapsulated and sent over a network in Azure, ie. Premium Storage is not directly attached to the host.

## 1.1.2 Shared Storage

A shared storage system, like Azure Files (SMB 3.0 file share), is the other option. Ideally, the container is simply able to communicate with the shared storage on its own, but in some cases, the host may have to do that on behalf of the container.

The advantages of this approach are:

* The volume can be made available for read+write across any number of containers across any number of nodes.

The disadvantages of this approach are:

* Due to protocol, multi-write capability, etc. this solution has much lower performance.
* If Azure Files is used, there is a protocol change for Linux

The product group is currently working on an Azure Files v2 which will have much higher performance and lower latency; the specifics are still to be determined, but this approach can continue to become more viable over time.

## 1.1.3 Replicated Disk

This approach lets you attach local disk to the nodes of the cluster, provision volumes, and then replicate the contents of those volumes to other nodes. This gives you the speed of local attached disk and the flexibility to host containers on any node like shared storage.

The advantages of this approach are:

* Premium Storage can be used to achieve lower latency, higher throughput, and more IOPS.
* The volume can be made available for read+write across some number of containers across some number of nodes (limits may apply so that replication is possible in a reasonable time).

The disadvantages of this approach are:

* The complexity of the solution is significantly higher so there is a greater chance for failure.
* Replication will add network traffic. If there is a lot of change data, it could be very significant.
* Durability of the data requires that each write is committed to a quorum of nodes before the block can be considered written successfully; this increases latency.

## 1.2.0 Cached vs. Direct

Caching IO calls, particularly in the case of public cloud servers where disk is separated physically from compute, can improve performance dramatically. I ran all benchmarks with caching and without to show the difference.

This gets a bit more confusing when you consider that there may be different places that caching could occur. The direct=1 flag I am using to bypass the cache only ensures that the OS is not caching data, but the disk caching could still be turned on for Azure Disks or other places. You can see the effect of Azure Disk caching in comparing the results of A.1.4 and A.1.5.

# 2.0.0 Comparison

The following chart should show the difference in performance between the different options:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Method | Category | Cached | | | Direct | | |
| IOPS | Latency | Throughput | IOPS | Latency | Throughput |
| A.1.1, A.1.2  Baseline with Azure Files | Shared Storage | 221,405 | 24 u | 885.62 MB/s | 876 | 9,120 u | 3.51 MB/s |
| A.1.3, A.1.5 Baseline with Azure P40 | Attached Disk | 214,784 | 25 u | 859.14 MB/s | 3,156 | 2,520 u | 12.63 MB/s |
| A.1.6, A.1.7 Baseline with Local SSD | Attached Disk | 221,967 | 26 u | 887.87 MB/s | 16,425 | 477 u | 65.70 MB/s |
| A.2.1, A.2.2 Kubernetes + Azure Files | Shared Storage | 8,474 | 862 u | 33.90 MB/s | 843 | 9,480 u | 3.37 MB/s |
| A.4.3, A.4.4 DC/OS Local Azure Files | Shared Storage | 9,481 | 833 u | 37.93 MB/s | 903 | 8,850 u | 3.61 MB/s |
| A.5.1, A.5.2 Swarm + CloudStor for Azure Files | Shared Storage | 10,650 | 724 u | 42.60 MB/s | 913 | 8,750 u | 3.65 MB/s |
| A.7.1, A.7.2 REX-Ray + Azure P40 | Attached Disk | 292,734 | 25 u | 1,143.60 MB/s | 2,529 | 3,155 u | 10.18 MB/s |
| A.3.1, A.3.2 Kubernetes + Azure P40 | Attached Disk | 24,709 | 248 u | 98.84 MB/s | 4,905 | 1,615 u | 19.62 MB/s |
| A.6.1, A.6.2 Portworx + Azure P40 (r:1) | Replicated Disk  (1 copy) | 260,580 | 26 u | 1,017.10 MB/s | 9,177 | 863 u | 36.71 MB/s |
| A.6.3, A.6.4 Portworx + Azure P40 (r:2) | Replicated Disk  (2 copies) | 265,193 | 26 u | 1,035.10 MB/s | 3,502 | 2,274 u | 14.01 MB/s |
| A.6.5, A.6.6 Portworx + Azure P40 (r:3) | Replicated Disk  (3 copies) | 275,941 | 25 u | 1,077.10 MB/s | 3,669 | 2,169 u | 14.68 MB/s |

Please remember that performance tests are not 100% consistent, so slight differences in performance between options should be considered similar.

The baselines all cache to the local SSD so it is not surprising that all those are the same for cached results. The baseline direct results should be considered optimal performance, so we know if anything exceeds those it is introducing some level of caching – the obvious case here is Portworx, which is clearly caching the volumes.

Portworx requires writes to be committed to a quorum of replicated nodes. A 3 node cluster was used, so as expected, the performance numbers are the same for 2 or 3 replicas (since both would have a 2 node quorum).

There are lots of variables that could change these performance numbers, for example, block size, encryption, priority, etc. Where decisions were made, the selected options are documented later.

# 3.0.0 Platform

There are multiple ways to deploy your choice of platform and orchestrator. Everything tested here could be deployed using ACS in one of the following ways:

* **ACS** – This option gives you a choice of Swarm, Kubernetes, or DC/OS for orchestrator. For Swarm and DC/OS, the worker/agent nodes are part of a VM Scale Set; for Kubernetes, the agents are in an Availability Set.
* **ACS Engine** – This option lets you define a model template for your cluster (same orchestrators as ACS) and then it will generate an ARM template to deploy that configuration to Azure. You have a wide range of options with this offering including choosing to deploy in VM Scale Sets or Availability Sets, deploying to a specific VNET/subnet, choosing software versions, etc.
* **ACS (AKS) –** Whereas the other 2 options are primarily about deployment, the AKS option gives you a managed environment. The only orchestrator option is Kubernetes. There is not much flexibility in how this is deployed today, but it will eventually be somewhere between ACS and ACS Engine.

# 4.0.0 Testing specifics

## 4.1.0 Baselines

The baseline tests were performed using:

* DS3v2 VM
* P40 disk
* Managed Disks
* General-Purpose Azure Storage Account v2 (for Files)

## 4.2.0 Kubernetes

You could use ACS to deploy Kubernetes, but a more featured experience can be had by using ACS (AKS). I used AKS for the testing in this document. The deployment will already have both plugins installed.

The steps for deploying a suitable environment are found here: <https://docs.microsoft.com/en-us/azure/aks/kubernetes-walkthrough-portal>.

The Kubernetes tests were performed using:

* Azure Container Service (AKS)
* DS3v2 VMs
* 3 nodes
* P40 disks
* Managed Disks

Azure Files testing followed this procedure: <https://docs.microsoft.com/en-us/azure/aks/azure-files-dynamic-pv>. Azure Disk testing followed this procedure: <https://docs.microsoft.com/en-us/azure/aks/azure-disks-dynamic-pv>.

## 4.3.0 DC/OS Local Azure Files

This DC/OS test was performed using:

* ACS
* DC/OS 1.9
* DS3v2 VMs
* 1 master node
* 3 private agent nodes
* 1 public agent node
* General-Purpose Azure Storage Account v2 (for Files)
* Containers used “Local Volumes” pointing to the Azure Files share

The Azure Files share was attached to each agent node in the cluster using the process and scripts described here: <https://docs.microsoft.com/en-us/azure/container-service/dcos-swarm/container-service-dcos-fileshare>.

## 4.4.0 Swarm CloudStor for Azure Files

You could use ACS to deploy a Swarm cluster, but I prefer the Docker for Azure deployment solution provided by Docker. I used the Docker solution for the testing conducted in this document. The deployment will already include the CloudStor for Azure plugin.

The steps for deploying a suitable environment are found here: <https://docs.docker.com/docker-for-azure/>.

The Docker test was performed using:

* Docker for Azure
* DS3v2 VMs
* 1 master node
* 3 worker nodes
* General-Purpose Azure Storage Account v2 (for Files)

The configuration for the share used by storage was per: <https://docs.docker.com/docker-for-azure/persistent-data-volumes>.

## 4.5.0 REX-Ray

To use REX-Ray with DC/OS, you must deploy in a specific way. The steps for deploying a suitable environment are:

1. Download ACS Engine.
2. Create an API model JSON file: <https://github.com/Azure/acs-engine>.
   1. You must use Availability Sets and unmanaged disks for the agents – no other configuration will work with REX-Ray. See the configuration details below.
   2. You must specify "orchestratorRelease": "1.10" under “properties” or you will run into this problem: <https://github.com/Azure/acs-engine/issues/565>. See the configuration details below.
   3. Make sure you specify “s” series VMs if you plan to attach Premium storage as used for these benchmarks.
   4. Make sure you specify a large enough series VM to cover your requirements for number of cores, RAM, number of disks you can attach, disk IOPS and throughput, and network bandwidth.
3. Generate the ARM template using ACS Engine.
4. Deploy the ARM template.
5. Create a new Storage Account (Premium to attach a P40 like was used for this testing).
6. You can use ssh to forward port 80 on the remote master node to your local machine allowing you to get to the DC/OS portal.
   1. ex. sudo ssh -i ~/.ssh/id\_rsa -p 2200 -fNL 80:localhost:80 plasne@pelasnedcosmj.eastus.cloudapp.azure.com
7. Use scp to copy the private ssh key to the master node.
   1. ex. scp -i ~/.ssh/id\_rsa -P 2200 ~/.ssh/id\_rsa [plasne@pelasnedcosmf.eastus.cloudapp.azure.com:~/.ssh](mailto:plasne@pelasnedcosmf.eastus.cloudapp.azure.com:~/.ssh)
8. Use ssh to connect to the master node and then from there you can ssh to each private agent. Do these steps on each agent:
   1. Change the master configuration for REX-Ray to look like the below using “sudo vi /opt/mesosphere/etc/rexray.conf”. You should read up on the options and particularly the options required for the App account here: <https://rexray.readthedocs.io/en/stable/user-guide/storage-providers/microsoft/>.

rexray:

loglevel: info

service: azureud

azureud:

subscriptionID: 83e686f6-963b-4e64-bff4-99dc369cb4ec

resourceGroup: pelasne-dcosj

tenantID: microsoft.onmicrosoft.com

storageAccount: pelasnerexray

storageAccessKey: 9…Q==

clientID: c…c

clientSecret: a…8=

container: vhds

* 1. Install lsscsi by “sudo apt-get update && sudo apt-get install lsscsi”.
  2. Stop the current running instance, it will restart almost immediately with the new configuration. “sudo /opt/mesosphere/packages/rexray--da7f17f8a4b772c0bac3f8d289a08abd4ff272b4/bin/rexray stop”
  3. You can make sure the new service is running with “sudo /opt/mesosphere/packages/rexray--da7f17f8a4b772c0bac3f8d289a08abd4ff272b4/bin/rexray status”. You should also see the process by running “ps aux | grep rexray”.
  4. You can validate the new configuration was applied by “cat /etc/rexray/config.yml”.

NOTE: I do want to call out one limitation with a REX-Ray configuration that is unique to the way it deploys with Azure Unmanaged Disks. Since each volume is attached to a VM as a disk, there is a limit to the number of volumes you could attach to each host.

{

"apiVersion": "vlabs",

"properties": {

"orchestratorProfile": {

"orchestratorType": "DCOS",

"orchestratorRelease": "1.10"

},

"masterProfile": {

"count": 1,

"dnsPrefix": "pelasnedcosmj",

"vmSize": "Standard\_DS4\_v2"

},

"agentPoolProfiles": [

{

"name": "agentprivate",

"count": 3,

"vmSize": "Standard\_DS4\_v2",

"availabilityProfile": "AvailabilitySet",

"storageProfile": "StorageAccount"

},

{

"name": "agentpublic",

"count": 1,

"vmSize": "Standard\_DS4\_v2",

"availabilityProfile": "AvailabilitySet",

"storageProfile": "StorageAccount",

"dnsPrefix": "pelasnedcosaj",

"ports": [

80,

443,

8080

]

}

],

"linuxProfile": {

"adminUsername": "plasne",

"ssh": {

"publicKeys": [

{

"keyData": "ssh-rsa AAA…LR5 plasne@Peters-iMac.local"

}

]

}

}

}

}

The REX-Ray test was performed using:

* ACS Engine
* DC/OS 1.10
* DS3v2 VMs
* 1 master
* 1 public agent
* 3 private agents
* Azure Storage Account Premium v1

## 4.6.0 Portworx

If you are going to use DC/OS for Portworx, you must install DC/OS using ACS Engine. The steps for deploying a suitable environment are:

1. Download ACS Engine.
2. Create an API model JSON file: <https://github.com/Azure/acs-engine>.
   1. You can use VM Scale Sets as they deploy using Managed Disks.
   2. You must specify "orchestratorRelease": "1.10" under “properties” or you will run into this problem: <https://github.com/Azure/acs-engine/issues/565>.
   3. You should add ports 9998 and 9999 under “properties/agentPoolProfiles/ports” if you plan to use Lighthouse (the Portworx management tool).
   4. Make sure you specify “s” series VMs if you plan to attach Premium storage as used for these benchmarks.
   5. Make sure you specify a large enough series VM to cover your requirements for number of cores, RAM, number of disks you can attach, disk IOPS and throughput, and network bandwidth.
3. Generate the ARM template using ACS Engine.
4. Deploy the ARM template.
5. A data disk was mounted to the ***private agent*** VM Scale Set using: <https://docs.microsoft.com/en-us/cli/azure/vmss/disk?view=azure-cli-latest>.
6. Each instance in the VMSS must be upgraded to the new model (a Premium Managed data disk added to each) in the Instances panel in the portal.
7. You do not need to format or mount the disk, this will be handled by Portworx.
8. You can use ssh to forward port 80 on the remote master node to your local machine allowing you to get to the DC/OS portal.
   1. ex. sudo ssh -i ~/.ssh/id\_rsa -p 2200 -fNL 80:localhost:80 [plasne@pelasnedcosmf.eastus.cloudapp.azure.com](mailto:plasne@pelasnedcosmf.eastus.cloudapp.azure.com)
9. In the DC/OS portal you can then deploy the “portworx” package using “Advanced” to deploy all the above containers.
10. When the deployment is done, you can deploy “reproxy” to expose Lighthouse (the Portworx admin tool): <https://docs.portworx.com/scheduler/mesosphere-dcos/install.html#accessing-lighthouse>.
11. In theory, this deployment would have resulted in a cluster being created and the Portworx container being deployed to each private agent, however that did not happen for me in any of the tests, so continue with the following steps.
12. Go into the Lighthouse portal and create a cluster.
    1. While the package prompts you for a password for Lighthouse, it doesn’t seem to apply it, instead you must use the default “admin” password.
13. Use scp to copy the private ssh key to the master node.
    1. ex. scp -i ~/.ssh/id\_rsa -P 2200 ~/.ssh/id\_rsa [plasne@pelasnedcosmf.eastus.cloudapp.azure.com:~/.ssh](mailto:plasne@pelasnedcosmf.eastus.cloudapp.azure.com:~/.ssh)
14. Use ssh to connect to the master node and then from there you can ssh to each private agent. Do these steps on each agent:
    1. Run the following commands to remove the PX-OCI installation: <https://docs.portworx.com/runc/#uninstalling-the-px-oci-bundle>. This deployment has a bad configuration.
    2. In the Lighthouse portal under “Manage Clusters”, click “Get Startup Script”, copy the first block.
    3. Run the copied command on the agent.
       1. Select the sdc disk when prompted.
       2. Select the eth0 NIC when prompted.
    4. NOTE: If you want to use the PX-OCI installation, it can be repaired by stopping the service, running the “px-runc install” command with all the appropriate options, then restart the service.
15. After these steps you should be able to see all nodes in the Lighthouse interface.
    1. NOTE: The nodes often showed “Error” status in Lighthouse even as “pxctl status” showed everything fine and even as the volumes continued to work. I don’t know what the problem is.
16. Volumes can be created per: <https://docs.portworx.com/manage/volumes.html>.

Portworx offers a preinstall tool that you could run on any of the nodes: <https://docs.portworx.com/install/preinstallcheck.html>. There are several things that need to be checked, such as the Docker version being 13.0+ and MOUNTFLAGS=SLAVE being disabled, but all those things should be correct out-of-the-box with DC/OS version 1.10.0+.

You cannot update or rerun the “portworx” package after you run it once unless you go through a complete uninstall process - if you simply remove the package there are still remnants in Zookeeper and on the agent nodes. This page (<https://docs.portworx.com/scheduler/mesosphere-dcos/framework-cleanup.html>) has roughly what you need to do, but it doesn’t even list all the Zookeeper pieces. While, I could probably provide some guidance, it would be best to work a support ticket with Portworx if you need to uninstall.

If you did not put ports 9998 and 9999 into the ACS Engine API model, you will need to follow the instructions here: <https://docs.microsoft.com/en-us/azure/container-service/dcos-swarm/container-service-enable-public-access>, to open the ports in the ***public agent*** load balancer and Network Security Group.

The Portworx tests were conducted using the following:

* ACS Engine
* DS4v2 VMs
* 1 master node
* 3 private agent nodes
* 1 public agent node
* P40 disks (1 per private agent node)

DS4v2 was used instead of DS3v2 because the Portworx infrastructure needed to be deployed. Portworx deploys the following containers:

* etcd proxy
* 3x etcd nodes
* influx db
* lighthouse
* portworx

…which requires the following resources:

* 3.7 cores
* 8 GB RAM
* 16 GB Local Disk

# A.0.0: Full Test Results

All tests were run with the following commands:

### A.0.1 Cached

fio --name=randwrite --ioengine=libaio --iodepth=1 --rw=randwrite --bs=4k --direct=0 --size=256M --numjobs=8 --runtime=240 --group\_reporting --directory /mnt/vol0

### A.0.2 Direct

fio --name=randwrite --ioengine=libaio --iodepth=1 --rw=randwrite --bs=4k --direct=1 --size=256M --numjobs=8 --runtime=240 --group\_reporting --directory /mnt/vol0

## A.1.0 Baselines

### A.1.1 Azure Files, Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=16747: Wed Mar 7 16:18:23 2018

write: io=2048.0MB, bw=885622KB/s, iops=221405, runt= 2368msec

slat (usec): min=5, max=53771, avg=15.23, stdev=310.67

clat (usec): min=2, max=32514, avg= 6.05, stdev=186.94

lat (usec): min=9, max=53778, avg=24.28, stdev=388.30

clat percentiles (usec):

| 1.00th=[ 2], 5.00th=[ 2], 10.00th=[ 3], 20.00th=[ 3],

| 30.00th=[ 3], 40.00th=[ 3], 50.00th=[ 3], 60.00th=[ 3],

| 70.00th=[ 3], 80.00th=[ 3], 90.00th=[ 3], 95.00th=[ 3],

| 99.00th=[ 4], 99.50th=[ 12], 99.90th=[ 35], 99.95th=[ 330],

| 99.99th=[11968]

bw (KB /s): min=93129, max=150016, per=12.97%, avg=114827.53, stdev=9137.97

lat (usec) : 4=97.72%, 10=1.73%, 20=0.37%, 50=0.09%, 100=0.02%

lat (usec) : 250=0.01%, 500=0.02%, 750=0.01%, 1000=0.01%

lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.02%, 50=0.01%

cpu : usr=17.61%, sys=31.84%, ctx=1354, majf=0, minf=87

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=885621KB/s, minb=885621KB/s, maxb=885621KB/s, mint=2368msec, maxt=2368msec

### A.1.2 Azure Files, Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=16798: Wed Mar 7 16:22:54 2018

write: io=841780KB, bw=3505.8KB/s, iops=876, runt=240116msec

slat (usec): min=49, max=11336, avg=117.04, stdev=103.20

clat (msec): min=2, max=671, avg= 9.00, stdev=19.64

lat (msec): min=2, max=671, avg= 9.12, stdev=19.65

clat percentiles (msec):

| 1.00th=[ 4], 5.00th=[ 4], 10.00th=[ 4], 20.00th=[ 4],

| 30.00th=[ 4], 40.00th=[ 4], 50.00th=[ 4], 60.00th=[ 4],

| 70.00th=[ 5], 80.00th=[ 5], 90.00th=[ 8], 95.00th=[ 55],

| 99.00th=[ 99], 99.50th=[ 110], 99.90th=[ 153], 99.95th=[ 192],

| 99.99th=[ 233]

bw (KB /s): min= 62, max= 733, per=12.56%, avg=440.09, stdev=85.50

lat (msec) : 4=61.78%, 10=29.46%, 20=1.71%, 50=1.70%, 100=4.43%

lat (msec) : 250=0.91%, 500=0.01%, 750=0.01%

cpu : usr=0.15%, sys=1.23%, ctx=253258, majf=0, minf=87

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=210445/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=841780KB, aggrb=3505KB/s, minb=3505KB/s, maxb=3505KB/s, mint=240116msec, maxt=240116msec

### A.1.3 P40, Cached (direct=0 and Azure Disk read/write cache)

randwrite: (groupid=0, jobs=8): err= 0: pid=14339: Wed Mar 7 15:33:47 2018

write: io=2048.0MB, bw=859136KB/s, iops=214784, runt= 2441msec

slat (usec): min=5, max=20447, avg=16.44, stdev=311.60

clat (usec): min=2, max=24872, avg= 5.98, stdev=184.03

lat (usec): min=9, max=31437, avg=25.34, stdev=387.27

clat percentiles (usec):

| 1.00th=[ 2], 5.00th=[ 2], 10.00th=[ 2], 20.00th=[ 3],

| 30.00th=[ 3], 40.00th=[ 3], 50.00th=[ 3], 60.00th=[ 3],

| 70.00th=[ 3], 80.00th=[ 3], 90.00th=[ 3], 95.00th=[ 3],

| 99.00th=[ 4], 99.50th=[ 12], 99.90th=[ 43], 99.95th=[ 322],

| 99.99th=[11968]

bw (KB /s): min=90139, max=126921, per=12.72%, avg=109295.12, stdev=9352.51

lat (usec) : 4=95.87%, 10=3.58%, 20=0.35%, 50=0.12%, 100=0.02%

lat (usec) : 250=0.01%, 500=0.02%, 750=0.01%, 1000=0.01%

lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.02%, 50=0.01%

cpu : usr=17.49%, sys=32.74%, ctx=973, majf=0, minf=88

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=859136KB/s, minb=859136KB/s, maxb=859136KB/s, mint=2441msec, maxt=2441msec

### A.1.4 P40, Direct (Azure Disk read/write cache)

randwrite: (groupid=0, jobs=8): err= 0: pid=14476: Wed Mar 7 15:36:50 2018

write: io=2048.0MB, bw=64777KB/s, iops=16194, runt= 32375msec

slat (usec): min=7, max=9089, avg=15.09, stdev=42.55

clat (usec): min=2, max=188330, avg=465.77, stdev=3253.18

lat (usec): min=24, max=188342, avg=482.83, stdev=3253.75

clat percentiles (usec):

| 1.00th=[ 35], 5.00th=[ 55], 10.00th=[ 65], 20.00th=[ 81],

| 30.00th=[ 98], 40.00th=[ 117], 50.00th=[ 137], 60.00th=[ 151],

| 70.00th=[ 163], 80.00th=[ 177], 90.00th=[ 203], 95.00th=[ 253],

| 99.00th=[ 9664], 99.50th=[32384], 99.90th=[35584], 99.95th=[38144],

| 99.99th=[43264]

bw (KB /s): min= 5272, max= 9732, per=12.51%, avg=8103.39, stdev=583.97

lat (usec) : 4=0.33%, 10=0.30%, 20=0.07%, 50=2.69%, 100=27.47%

lat (usec) : 250=64.04%, 500=3.04%, 750=0.55%, 1000=0.14%

lat (msec) : 2=0.17%, 4=0.10%, 10=0.12%, 20=0.03%, 50=0.96%

lat (msec) : 100=0.01%, 250=0.01%

cpu : usr=1.99%, sys=5.14%, ctx=526761, majf=0, minf=88

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=64776KB/s, minb=64776KB/s, maxb=64776KB/s, mint=32375msec, maxt=32375msec

### A.1.5 P40, Direct (Azure Disk no cache)

randwrite: (groupid=0, jobs=8): err= 0: pid=15128: Wed Mar 7 15:50:33 2018

write: io=2048.0MB, bw=12627KB/s, iops=3156, runt=166082msec

slat (usec): min=7, max=12482, avg=21.12, stdev=62.11

clat (usec): min=3, max=481611, avg=2499.11, stdev=1918.43

lat (msec): min=1, max=481, avg= 2.52, stdev= 1.92

clat percentiles (usec):

| 1.00th=[ 1960], 5.00th=[ 2064], 10.00th=[ 2128], 20.00th=[ 2224],

| 30.00th=[ 2288], 40.00th=[ 2352], 50.00th=[ 2448], 60.00th=[ 2512],

| 70.00th=[ 2576], 80.00th=[ 2640], 90.00th=[ 2768], 95.00th=[ 2928],

| 99.00th=[ 4512], 99.50th=[ 5920], 99.90th=[ 8896], 99.95th=[ 9920],

| 99.99th=[14656]

bw (KB /s): min= 7, max= 1724, per=12.53%, avg=1581.70, stdev=100.21

lat (usec) : 4=0.01%, 10=0.01%, 100=0.01%, 1000=0.01%

lat (msec) : 2=1.96%, 4=96.63%, 10=1.36%, 20=0.04%, 50=0.01%

lat (msec) : 100=0.01%, 500=0.01%

cpu : usr=0.55%, sys=1.27%, ctx=526883, majf=0, minf=92

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=12627KB/s, minb=12627KB/s, maxb=12627KB/s, mint=166082msec, maxt=166082msec

### A.1.6 Local SSD, Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=16147: Wed Mar 7 16:07:55 2018

write: io=2048.0MB, bw=887871KB/s, iops=221967, runt= 2362msec

slat (usec): min=6, max=26203, avg=15.94, stdev=308.65

clat (usec): min=2, max=20553, avg= 6.44, stdev=195.06

lat (usec): min=10, max=26209, avg=25.77, stdev=396.34

clat percentiles (usec):

| 1.00th=[ 2], 5.00th=[ 2], 10.00th=[ 3], 20.00th=[ 3],

| 30.00th=[ 3], 40.00th=[ 3], 50.00th=[ 3], 60.00th=[ 3],

| 70.00th=[ 3], 80.00th=[ 3], 90.00th=[ 3], 95.00th=[ 4],

| 99.00th=[ 4], 99.50th=[ 14], 99.90th=[ 42], 99.95th=[ 314],

| 99.99th=[11968]

bw (KB /s): min=99634, max=129055, per=12.59%, avg=111805.34, stdev=6273.32

lat (usec) : 4=90.54%, 10=8.79%, 20=0.42%, 50=0.16%, 100=0.02%

lat (usec) : 250=0.01%, 500=0.02%, 750=0.01%, 1000=0.01%

lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.02%, 50=0.01%

cpu : usr=17.77%, sys=32.76%, ctx=1560, majf=0, minf=90

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=887871KB/s, minb=887871KB/s, maxb=887871KB/s, mint=2362msec, maxt=2362msec

### A.1.7 Local SSD, Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=16050: Wed Mar 7 16:06:43 2018

write: io=2048.0MB, bw=65700KB/s, iops=16425, runt= 31920msec

slat (usec): min=11, max=8215, avg=28.09, stdev=48.32

clat (usec): min=3, max=39570, avg=445.68, stdev=2868.95

lat (usec): min=76, max=39604, avg=476.94, stdev=2869.44

clat percentiles (usec):

| 1.00th=[ 17], 5.00th=[ 82], 10.00th=[ 95], 20.00th=[ 106],

| 30.00th=[ 114], 40.00th=[ 122], 50.00th=[ 129], 60.00th=[ 139],

| 70.00th=[ 153], 80.00th=[ 183], 90.00th=[ 318], 95.00th=[ 462],

| 99.00th=[ 4256], 99.50th=[31104], 99.90th=[33024], 99.95th=[33536],

| 99.99th=[34048]

bw (KB /s): min= 6624, max= 9024, per=12.52%, avg=8223.54, stdev=307.37

lat (usec) : 4=0.46%, 10=0.48%, 20=0.09%, 50=1.03%, 100=11.06%

lat (usec) : 250=74.02%, 500=8.82%, 750=2.31%, 1000=0.33%

lat (msec) : 2=0.28%, 4=0.12%, 10=0.10%, 20=0.05%, 50=0.86%

cpu : usr=2.04%, sys=6.22%, ctx=639942, majf=0, minf=82

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=65700KB/s, minb=65700KB/s, maxb=65700KB/s, mint=31920msec, maxt=31920msec

## A.2.0 Microsoft Kubernetes Plugin for Azure Files

<https://docs.microsoft.com/en-us/azure/aks/azure-files-dynamic-pv>

### A.2.1 Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=573: Sat Feb 24 01:53:35 2018

  write: io=2048.0MB, bw=33897KB/s, iops=8474, runt= 61868msec

    slat (usec): min=1, max=208627, avg=860.66, stdev=7746.24

    clat (usec): min=0, max=26922, avg= 1.13, stdev=97.65

     lat (usec): min=1, max=208629, avg=862.30, stdev=7747.58

    clat percentiles (usec):

     |  1.00th=[    0],  5.00th=[    0], 10.00th=[    0], 20.00th=[    0],

     | 30.00th=[    0], 40.00th=[    0], 50.00th=[    0], 60.00th=[    1],

     | 70.00th=[    1], 80.00th=[    1], 90.00th=[    1], 95.00th=[    1],

     | 99.00th=[    2], 99.50th=[    3], 99.90th=[   16], 99.95th=[   33],

     | 99.99th=[  378]

    bw (KB  /s): min= 1068, max=256938, per=12.42%, avg=4208.79, stdev=16266.26

    lat (usec) : 2=98.44%, 4=1.11%, 10=0.25%, 20=0.11%, 50=0.05%

    lat (usec) : 100=0.01%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%, 50=0.01%

  cpu          : usr=0.17%, sys=0.42%, ctx=9805, majf=0, minf=72

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=2048.0MB, aggrb=33897KB/s, minb=33897KB/s, maxb=33897KB/s, mint=61868msec, maxt=61868msec

### A.2.2 Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=583: Sat Feb 24 02:00:05 2018

  write: io=809624KB, bw=3372.7KB/s, iops=843, runt=240055msec

    slat (msec): min=2, max=343, avg= 9.48, stdev=19.91

    clat (usec): min=0, max=5673, avg= 2.52, stdev=22.89

     lat (msec): min=2, max=343, avg= 9.48, stdev=19.91

    clat percentiles (usec):

     |  1.00th=[    1],  5.00th=[    1], 10.00th=[    1], 20.00th=[    1],

     | 30.00th=[    1], 40.00th=[    2], 50.00th=[    2], 60.00th=[    2],

     | 70.00th=[    2], 80.00th=[    2], 90.00th=[    3], 95.00th=[    4],

     | 99.00th=[   14], 99.50th=[   30], 99.90th=[  121], 99.95th=[  193],

     | 99.99th=[  378]

    bw (KB  /s): min=  108, max=  772, per=12.54%, avg=422.83, stdev=82.91

    lat (usec) : 2=34.06%, 4=58.70%, 10=5.91%, 20=0.64%, 50=0.43%

    lat (usec) : 100=0.13%, 250=0.09%, 500=0.03%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 10=0.01%

  cpu          : usr=0.08%, sys=0.91%, ctx=258349, majf=0, minf=71

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=202406/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=809624KB, aggrb=3372KB/s, minb=3372KB/s, maxb=3372KB/s, mint=240055msec, maxt=240055msec

## A.3.0 Microsoft Kubernetes Plugin for Azure Page Storage (P40)

<https://docs.microsoft.com/en-us/azure/aks/azure-disks-dynamic-pv>

### A.3.1 Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=628: Sat Feb 24 02:04:19 2018

  write: io=2048.0MB, bw=98838KB/s, iops=24709, runt= 21218msec

    slat (usec): min=1, max=51977, avg=247.20, stdev=2861.34

    clat (usec): min=0, max=24043, avg= 0.84, stdev=78.51

     lat (usec): min=1, max=51979, avg=248.46, stdev=2863.43

    clat percentiles (usec):

     |  1.00th=[    0],  5.00th=[    0], 10.00th=[    0], 20.00th=[    0],

     | 30.00th=[    0], 40.00th=[    0], 50.00th=[    0], 60.00th=[    0],

     | 70.00th=[    1], 80.00th=[    1], 90.00th=[    1], 95.00th=[    1],

     | 99.00th=[    1], 99.50th=[    2], 99.90th=[   13], 99.95th=[   20],

     | 99.99th=[   73]

    bw (KB  /s): min= 5973, max=277254, per=16.10%, avg=15908.61, stdev=30890.90

    lat (usec) : 2=99.12%, 4=0.56%, 10=0.14%, 20=0.13%, 50=0.04%

    lat (usec) : 100=0.01%, 250=0.01%, 500=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%, 50=0.01%

  cpu          : usr=0.29%, sys=2.01%, ctx=4969, majf=0, minf=88

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=2048.0MB, aggrb=98838KB/s, minb=98838KB/s, maxb=98838KB/s, mint=21218msec, maxt=21218msec

### A.3.2 Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=641: Sat Feb 24 02:10:39 2018

  write: io=2048.0MB, bw=19620KB/s, iops=4905, runt=106886msec

    slat (usec): min=3, max=10271, avg=12.43, stdev=37.28

    clat (usec): min=0, max=18361K, avg=1601.69, stdev=98829.25

     lat (usec): min=24, max=18361K, avg=1614.64, stdev=98829.84

    clat percentiles (usec):

     |  1.00th=[   33],  5.00th=[   43], 10.00th=[   49], 20.00th=[   57],

     | 30.00th=[   65], 40.00th=[   74], 50.00th=[   83], 60.00th=[   96],

     | 70.00th=[  112], 80.00th=[  135], 90.00th=[  177], 95.00th=[  247],

     | 99.00th=[43776], 99.50th=[44800], 99.90th=[45824], 99.95th=[45824],

     | 99.99th=[53504]

    bw (KB  /s): min=    8, max= 8064, per=20.42%, avg=4007.23, stdev=798.22

    lat (usec) : 2=0.20%, 4=0.04%, 10=0.01%, 20=0.03%, 50=9.99%

    lat (usec) : 100=52.49%, 250=32.37%, 500=2.25%, 750=0.29%, 1000=0.12%

    lat (msec) : 2=0.13%, 4=0.07%, 10=0.05%, 20=0.02%, 50=1.91%

    lat (msec) : 100=0.02%, >=2000=0.01%

  cpu          : usr=0.26%, sys=1.12%, ctx=528947, majf=0, minf=102

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=2048.0MB, aggrb=19620KB/s, minb=19620KB/s, maxb=19620KB/s, mint=106886msec, maxt=106886msec

## A.4.0 DC/OS Local Mounted Volume on Azure Files

<https://docs.microsoft.com/en-us/azure/container-service/dcos-swarm/container-service-dcos-fileshare>

### A.4.1 Cached 128MB RAM

randwrite: (groupid=0, jobs=8): err= 0: pid=28: Tue Feb 27 23:19:11 2018

  write: io=1172.4MB, bw=4983.5KB/s, iops=1245, runt=240899msec

    slat (usec): min=3, max=4224.5K, avg=6402.47, stdev=80796.07

    clat (usec): min=0, max=16021, avg= 0.84, stdev=43.88

     lat (usec): min=3, max=4224.5K, avg=6403.83, stdev=80796.50

    clat percentiles (usec):

     |  1.00th=[    0],  5.00th=[    0], 10.00th=[    0], 20.00th=[    0],

     | 30.00th=[    0], 40.00th=[    0], 50.00th=[    1], 60.00th=[    1],

     | 70.00th=[    1], 80.00th=[    1], 90.00th=[    1], 95.00th=[    1],

     | 99.00th=[    2], 99.50th=[    4], 99.90th=[   26], 99.95th=[   49],

     | 99.99th=[  262]

    bw (KB  /s): min=    5, max=21071, per=13.93%, avg=694.35, stdev=1055.85

    lat (usec) : 2=98.56%, 4=0.77%, 10=0.38%, 20=0.15%, 50=0.09%

    lat (usec) : 100=0.02%, 250=0.02%, 500=0.01%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%

  cpu          : usr=0.03%, sys=0.15%, ctx=20797, majf=0, minf=50

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=300128/d=0, short=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=1172.4MB, aggrb=4983KB/s, minb=4983KB/s, maxb=4983KB/s, mint=240899msec, maxt=240899msec

### A.4.2 Cached 1024MB RAM

randwrite: (groupid=0, jobs=8): err= 0: pid=28: Tue Feb 27 23:48:39 2018

  write: io=2048.0MB, bw=26667KB/s, iops=6666, runt= 78642msec

    slat (usec): min=2, max=2157.8K, avg=1077.23, stdev=26192.24

    clat (usec): min=0, max=68038, avg= 2.27, stdev=272.47

     lat (usec): min=3, max=2157.8K, avg=1080.69, stdev=26194.39

    clat percentiles (usec):

     |  1.00th=[    0],  5.00th=[    0], 10.00th=[    0], 20.00th=[    0],

     | 30.00th=[    0], 40.00th=[    0], 50.00th=[    0], 60.00th=[    1],

     | 70.00th=[    1], 80.00th=[    1], 90.00th=[    1], 95.00th=[    1],

     | 99.00th=[    1], 99.50th=[    2], 99.90th=[   22], 99.95th=[   45],

     | 99.99th=[  684]

    bw (KB  /s): min=    6, max=197440, per=17.37%, avg=4631.72, stdev=15939.62

    lat (usec) : 2=99.39%, 4=0.28%, 10=0.12%, 20=0.10%, 50=0.06%

    lat (usec) : 100=0.02%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%, 50=0.01%

    lat (msec) : 100=0.01%

  cpu          : usr=0.17%, sys=0.60%, ctx=12706, majf=0, minf=52

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=2048.0MB, aggrb=26667KB/s, minb=26667KB/s, maxb=26667KB/s, mint=78642msec, maxt=78642msec

### A.4.3 Cached 4096MB RAM

randwrite: (groupid=0, jobs=8): err= 0: pid=28: Wed Feb 28 20:58:33 2018

write: io=2048.0MB, bw=37928KB/s, iops=9481, runt= 55293msec

slat (usec): min=2, max=203742, avg=829.35, stdev=8969.58

clat (usec): min=0, max=53801, avg= 2.28, stdev=242.55

lat (usec): min=3, max=203747, avg=833.32, stdev=8975.80

clat percentiles (usec):

| 1.00th=[ 0], 5.00th=[ 0], 10.00th=[ 0], 20.00th=[ 0],

| 30.00th=[ 0], 40.00th=[ 0], 50.00th=[ 1], 60.00th=[ 1],

| 70.00th=[ 1], 80.00th=[ 1], 90.00th=[ 1], 95.00th=[ 1],

| 99.00th=[ 2], 99.50th=[ 2], 99.90th=[ 14], 99.95th=[ 31],

| 99.99th=[ 1416]

bw (KB /s): min= 440, max=117777, per=12.94%, avg=4908.90, stdev=15219.41

lat (usec) : 2=98.87%, 4=0.91%, 10=0.06%, 20=0.08%, 50=0.04%

lat (usec) : 100=0.01%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%

lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%, 50=0.01%

lat (msec) : 100=0.01%

cpu : usr=0.24%, sys=0.58%, ctx=8027, majf=0, minf=51

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=37927KB/s, minb=37927KB/s, maxb=37927KB/s, mint=55293msec, maxt=55293msec

### A.4.4 Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=38: Tue Feb 27 23:26:07 2018

  write: io=867608KB, bw=3614.9KB/s, iops=903, runt=240012msec

    slat (msec): min=2, max=325, avg= 8.84, stdev=19.83

    clat (usec): min=0, max=2400, avg= 1.64, stdev= 9.06

     lat (msec): min=2, max=325, avg= 8.85, stdev=19.83

    clat percentiles (usec):

     |  1.00th=[    1],  5.00th=[    1], 10.00th=[    1], 20.00th=[    1],

     | 30.00th=[    1], 40.00th=[    1], 50.00th=[    1], 60.00th=[    1],

     | 70.00th=[    2], 80.00th=[    2], 90.00th=[    2], 95.00th=[    2],

     | 99.00th=[    4], 99.50th=[   14], 99.90th=[   67], 99.95th=[  106],

     | 99.99th=[  298]

    bw (KB  /s): min=  139, max=  816, per=12.55%, avg=453.58, stdev=94.49

    lat (usec) : 2=66.19%, 4=32.79%, 10=0.38%, 20=0.25%, 50=0.27%

    lat (usec) : 100=0.06%, 250=0.05%, 500=0.01%, 750=0.01%

    lat (msec) : 2=0.01%, 4=0.01%

  cpu          : usr=0.09%, sys=0.83%, ctx=253655, majf=0, minf=49

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=216902/d=0, short=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=867608KB, aggrb=3614KB/s, minb=3614KB/s, maxb=3614KB/s, mint=240012msec, maxt=240012msec

## A.5.0 Docker CloudStor for Azure

<https://docs.docker.com/docker-for-azure/persistent-data-volumes/>

### A.5.1 Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=551: Tue Feb 27 17:04:10 2018

  write: io=2048.0MB, bw=42603KB/s, iops=10650, runt= 49225msec

    slat (usec): min=4, max=219191, avg=707.36, stdev=7187.60

    clat (usec): min=2, max=49955, avg=11.29, stdev=418.74

     lat (usec): min=8, max=219196, avg=724.02, stdev=7204.53

    clat percentiles (usec):

     |  1.00th=[    2],  5.00th=[    2], 10.00th=[    2], 20.00th=[    3],

     | 30.00th=[    3], 40.00th=[    3], 50.00th=[    3], 60.00th=[    3],

     | 70.00th=[    3], 80.00th=[    3], 90.00th=[    3], 95.00th=[    4],

     | 99.00th=[   14], 99.50th=[   30], 99.90th=[  141], 99.95th=[ 1976],

     | 99.99th=[25728]

    bw (KB  /s): min=  579, max=65410, per=13.07%, avg=5567.97, stdev=13373.93

    lat (usec) : 4=90.62%, 10=7.94%, 20=0.77%, 50=0.31%, 100=0.23%

    lat (usec) : 250=0.06%, 500=0.01%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%, 10=0.01%, 20=0.01%, 50=0.02%

  cpu          : usr=0.73%, sys=1.61%, ctx=10308, majf=0, minf=82

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=524288/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=2048.0MB, aggrb=42603KB/s, minb=42603KB/s, maxb=42603KB/s, mint=49225msec, maxt=49225msec

### A.5.2 Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=561: Tue Feb 27 17:11:24 2018

  write: io=877004KB, bw=3653.8KB/s, iops=913, runt=240073msec

    slat (msec): min=2, max=353, avg= 8.74, stdev=21.17

    clat (usec): min=2, max=3504, avg= 4.76, stdev=13.08

     lat (msec): min=2, max=353, avg= 8.75, stdev=21.17

    clat percentiles (usec):

     |  1.00th=[    3],  5.00th=[    3], 10.00th=[    3], 20.00th=[    3],

     | 30.00th=[    4], 40.00th=[    4], 50.00th=[    4], 60.00th=[    4],

     | 70.00th=[    4], 80.00th=[    4], 90.00th=[    5], 95.00th=[    9],

     | 99.00th=[   20], 99.50th=[   34], 99.90th=[   92], 99.95th=[  129],

     | 99.99th=[  286]

    bw (KB  /s): min=  117, max=  788, per=12.55%, avg=458.52, stdev=104.41

    lat (usec) : 4=28.20%, 10=68.14%, 20=2.60%, 50=0.76%, 100=0.22%

    lat (usec) : 250=0.07%, 500=0.01%, 750=0.01%, 1000=0.01%

    lat (msec) : 2=0.01%, 4=0.01%

  cpu          : usr=0.13%, sys=0.62%, ctx=251903, majf=0, minf=72

  IO depths    : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

     submit    : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     complete  : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

     issued    : total=r=0/w=219251/d=0, short=r=0/w=0/d=0, drop=r=0/w=0/d=0

     latency   : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

  WRITE: io=877004KB, aggrb=3653KB/s, minb=3653KB/s, maxb=3653KB/s, mint=240073msec, maxt=240073msec

## A.6.0 Portworx on DC/OS (P40)

<https://portworx.com/>

### A.6.1 Cached, Relicas=1

randwrite: (groupid=0, jobs=8): err= 0: pid=31: Wed Mar 7 01:32:27 2018

write: io=2048.0MB, bw=1017.1MB/s, iops=260580, runt= 2012msec

slat (usec): min=3, max=80188, avg=19.95, stdev=1020.87

clat (usec): min=1, max=80173, avg= 5.37, stdev=526.74

lat (usec): min=5, max=80194, avg=26.14, stdev=1166.50

clat percentiles (usec):

| 1.00th=[ 1], 5.00th=[ 1], 10.00th=[ 1], 20.00th=[ 1],

| 30.00th=[ 1], 40.00th=[ 1], 50.00th=[ 1], 60.00th=[ 2],

| 70.00th=[ 2], 80.00th=[ 2], 90.00th=[ 2], 95.00th=[ 2],

| 99.00th=[ 2], 99.50th=[ 2], 99.90th=[ 33], 99.95th=[ 43],

| 99.99th=[ 169]

bw (KB /s): min=114984, max=157928, per=12.94%, avg=134905.23, stdev=11577.60

lat (usec) : 2=52.04%, 4=47.59%, 10=0.13%, 20=0.10%, 50=0.11%

lat (usec) : 100=0.02%, 250=0.01%, 500=0.01%, 750=0.01%

lat (msec) : 2=0.01%, 10=0.01%, 20=0.01%, 100=0.01%

cpu : usr=8.74%, sys=18.86%, ctx=698, majf=0, minf=61

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=1017.1MB/s, minb=1017.1MB/s, maxb=1017.1MB/s, mint=2012msec, maxt=2012msec

### A.6.2 Direct, Relicas=1

randwrite: (groupid=0, jobs=8): err= 0: pid=41: Wed Mar 7 01:34:26 2018

write: io=2048.0MB, bw=36710KB/s, iops=9177, runt= 57128msec

slat (usec): min=5, max=8115, avg=16.03, stdev=22.53

clat (usec): min=2, max=221471, avg=847.23, stdev=2544.87

lat (usec): min=356, max=221492, avg=863.70, stdev=2545.21

clat percentiles (usec):

| 1.00th=[ 442], 5.00th=[ 486], 10.00th=[ 516], 20.00th=[ 556],

| 30.00th=[ 596], 40.00th=[ 636], 50.00th=[ 676], 60.00th=[ 724],

| 70.00th=[ 796], 80.00th=[ 892], 90.00th=[ 1048], 95.00th=[ 1224],

| 99.00th=[ 2768], 99.50th=[ 5088], 99.90th=[23168], 99.95th=[35584],

| 99.99th=[124416]

bw (KB /s): min= 2520, max= 5740, per=12.56%, avg=4611.41, stdev=587.94

lat (usec) : 4=0.01%, 50=0.01%, 100=0.01%, 250=0.01%, 500=7.23%

lat (usec) : 750=56.56%, 1000=24.10%

lat (msec) : 2=10.56%, 4=0.84%, 10=0.48%, 20=0.11%, 50=0.09%

lat (msec) : 100=0.02%, 250=0.02%

cpu : usr=0.82%, sys=2.53%, ctx=526330, majf=0, minf=69

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=36709KB/s, minb=36709KB/s, maxb=36709KB/s, mint=57128msec, maxt=57128msec

### A.6.3 Cached, Relicas=2

randwrite: (groupid=0, jobs=8): err= 0: pid=32: Wed Mar 7 14:43:46 2018

write: io=2048.0MB, bw=1035.1MB/s, iops=265193, runt= 1977msec

slat (usec): min=3, max=85158, avg=19.52, stdev=1011.15

clat (usec): min=1, max=80191, avg= 5.34, stdev=530.26

lat (usec): min=4, max=85165, avg=26.25, stdev=1178.79

clat percentiles (usec):

| 1.00th=[ 1], 5.00th=[ 1], 10.00th=[ 1], 20.00th=[ 1],

| 30.00th=[ 1], 40.00th=[ 1], 50.00th=[ 1], 60.00th=[ 2],

| 70.00th=[ 2], 80.00th=[ 2], 90.00th=[ 2], 95.00th=[ 2],

| 99.00th=[ 2], 99.50th=[ 2], 99.90th=[ 31], 99.95th=[ 44],

| 99.99th=[ 314]

bw (KB /s): min=112424, max=157937, per=12.83%, avg=136104.12, stdev=11669.54

lat (usec) : 2=57.67%, 4=41.99%, 10=0.11%, 20=0.10%, 50=0.10%

lat (usec) : 100=0.02%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%

lat (msec) : 10=0.01%, 100=0.01%

cpu : usr=9.02%, sys=18.54%, ctx=580, majf=0, minf=76

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=1035.1MB/s, minb=1035.1MB/s, maxb=1035.1MB/s, mint=1977msec, maxt=1977msec

### A.6.4 Direct, Relicas=2

randwrite: (groupid=0, jobs=8): err= 0: pid=43: Wed Mar 7 14:46:56 2018

write: io=2048.0MB, bw=14011KB/s, iops=3502, runt=149682msec

slat (usec): min=5, max=82325, avg=33.15, stdev=390.60

clat (usec): min=1, max=339199, avg=2240.56, stdev=13396.62

lat (usec): min=370, max=339208, avg=2274.28, stdev=13410.63

clat percentiles (usec):

| 1.00th=[ 450], 5.00th=[ 516], 10.00th=[ 548], 20.00th=[ 604],

| 30.00th=[ 652], 40.00th=[ 700], 50.00th=[ 748], 60.00th=[ 812],

| 70.00th=[ 892], 80.00th=[ 1020], 90.00th=[ 1400], 95.00th=[ 2704],

| 99.00th=[33536], 99.50th=[103936], 99.90th=[220160], 99.95th=[238592],

| 99.99th=[288768]

bw (KB /s): min= 416, max= 3360, per=12.61%, avg=1766.95, stdev=516.20

lat (usec) : 2=0.01%, 4=0.07%, 10=0.01%, 20=0.01%, 50=0.01%

lat (usec) : 100=0.01%, 250=0.05%, 500=3.38%, 750=46.23%, 1000=28.98%

lat (msec) : 2=14.80%, 4=2.79%, 10=2.04%, 20=0.35%, 50=0.43%

lat (msec) : 100=0.34%, 250=0.48%, 500=0.04%

cpu : usr=0.29%, sys=1.02%, ctx=615481, majf=0, minf=62

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=14010KB/s, minb=14010KB/s, maxb=14010KB/s, mint=149682msec, maxt=149682msec

### A.6.5 Cached, Relicas=3

randwrite: (groupid=0, jobs=8): err= 0: pid=29: Wed Mar 7 14:53:06 2018

write: io=2048.0MB, bw=1077.1MB/s, iops=275941, runt= 1900msec

slat (usec): min=3, max=80148, avg=19.26, stdev=1009.32

clat (usec): min=1, max=76207, avg= 5.11, stdev=512.37

lat (usec): min=4, max=80152, avg=25.04, stdev=1145.97

clat percentiles (usec):

| 1.00th=[ 1], 5.00th=[ 1], 10.00th=[ 1], 20.00th=[ 1],

| 30.00th=[ 1], 40.00th=[ 1], 50.00th=[ 1], 60.00th=[ 2],

| 70.00th=[ 2], 80.00th=[ 2], 90.00th=[ 2], 95.00th=[ 2],

| 99.00th=[ 2], 99.50th=[ 2], 99.90th=[ 21], 99.95th=[ 30],

| 99.99th=[ 110]

bw (KB /s): min=123664, max=160472, per=12.74%, avg=140633.67, stdev=9048.57

lat (usec) : 2=55.66%, 4=44.05%, 10=0.05%, 20=0.13%, 50=0.09%

lat (usec) : 100=0.01%, 250=0.01%, 500=0.01%, 750=0.01%

lat (msec) : 2=0.01%, 100=0.01%

cpu : usr=8.66%, sys=18.78%, ctx=502, majf=0, minf=60

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=1077.1MB/s, minb=1077.1MB/s, maxb=1077.1MB/s, mint=1900msec, maxt=1900msec

### A.6.6 Direct, Relicas=3

randwrite: (groupid=0, jobs=8): err= 0: pid=39: Wed Mar 7 14:55:42 2018

write: io=2048.0MB, bw=14678KB/s, iops=3669, runt=142879msec

slat (usec): min=5, max=564337, avg=48.40, stdev=1597.95

clat (usec): min=1, max=590084, avg=2120.19, stdev=13133.38

lat (usec): min=382, max=914385, avg=2169.33, stdev=13361.88

clat percentiles (usec):

| 1.00th=[ 438], 5.00th=[ 510], 10.00th=[ 540], 20.00th=[ 588],

| 30.00th=[ 620], 40.00th=[ 660], 50.00th=[ 700], 60.00th=[ 748],

| 70.00th=[ 812], 80.00th=[ 908], 90.00th=[ 1176], 95.00th=[ 2192],

| 99.00th=[31872], 99.50th=[96768], 99.90th=[205824], 99.95th=[236544],

| 99.99th=[305152]

bw (KB /s): min= 3, max= 3128, per=12.64%, avg=1854.98, stdev=557.65

lat (usec) : 2=0.01%, 4=0.08%, 10=0.01%, 20=0.01%, 50=0.01%

lat (usec) : 100=0.01%, 250=0.08%, 500=3.91%, 750=56.79%, 1000=24.18%

lat (msec) : 2=9.59%, 4=2.08%, 10=1.62%, 20=0.36%, 50=0.43%

lat (msec) : 100=0.37%, 250=0.45%, 500=0.03%, 750=0.01%

cpu : usr=0.29%, sys=1.15%, ctx=658285, majf=0, minf=61

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=14677KB/s, minb=14677KB/s, maxb=14677KB/s, mint=142879msec, maxt=142879msec

## A.7.0 REX-Ray on DC/OS (P40)

<https://rexray.io/>

### A.7.1 Cached

randwrite: (groupid=0, jobs=8): err= 0: pid=32: Mon Mar 12 22:50:47 2018

write: io=2048.0MB, bw=1143.6MB/s, iops=292734, runt= 1791msec

slat (usec): min=3, max=80169, avg=17.77, stdev=962.24

clat (usec): min=1, max=80162, avg= 5.83, stdev=568.93

lat (usec): min=4, max=80173, avg=24.51, stdev=1139.63

clat percentiles (usec):

| 1.00th=[ 1], 5.00th=[ 1], 10.00th=[ 1], 20.00th=[ 1],

| 30.00th=[ 1], 40.00th=[ 1], 50.00th=[ 1], 60.00th=[ 1],

| 70.00th=[ 2], 80.00th=[ 2], 90.00th=[ 2], 95.00th=[ 2],

| 99.00th=[ 2], 99.50th=[ 2], 99.90th=[ 23], 99.95th=[ 34],

| 99.99th=[ 114]

bw (KB /s): min=123072, max=169947, per=12.44%, avg=145608.21, stdev=13079.99

lat (usec) : 2=61.23%, 4=38.46%, 10=0.08%, 20=0.11%, 50=0.08%

lat (usec) : 100=0.01%, 250=0.01%, 500=0.01%, 750=0.01%, 1000=0.01%

lat (msec) : 2=0.01%, 100=0.01%

cpu : usr=8.84%, sys=19.43%, ctx=431, majf=0, minf=62

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=1143.6MB/s, minb=1143.6MB/s, maxb=1143.6MB/s, mint=1791msec, maxt=1791msec

### A.6.2 Direct

randwrite: (groupid=0, jobs=8): err= 0: pid=42: Mon Mar 12 22:54:37 2018

write: io=2048.0MB, bw=10117KB/s, iops=2529, runt=207299msec

slat (usec): min=4, max=14389, avg=16.40, stdev=55.60

clat (usec): min=861, max=94601, avg=3138.44, stdev=564.11

lat (usec): min=2140, max=94617, avg=3155.30, stdev=567.07

clat percentiles (usec):

| 1.00th=[ 2512], 5.00th=[ 2672], 10.00th=[ 2768], 20.00th=[ 2896],

| 30.00th=[ 2960], 40.00th=[ 2992], 50.00th=[ 3056], 60.00th=[ 3120],

| 70.00th=[ 3216], 80.00th=[ 3344], 90.00th=[ 3504], 95.00th=[ 3696],

| 99.00th=[ 4704], 99.50th=[ 5664], 99.90th=[ 7648], 99.95th=[ 9024],

| 99.99th=[19072]

bw (KB /s): min= 840, max= 1352, per=12.52%, avg=1266.48, stdev=34.27

lat (usec) : 1000=0.01%

lat (msec) : 2=0.01%, 4=97.51%, 10=2.46%, 20=0.02%, 50=0.01%

lat (msec) : 100=0.01%

cpu : usr=0.26%, sys=0.74%, ctx=525206, majf=0, minf=68

IO depths : 1=100.0%, 2=0.0%, 4=0.0%, 8=0.0%, 16=0.0%, 32=0.0%, >=64=0.0%

submit : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

complete : 0=0.0%, 4=100.0%, 8=0.0%, 16=0.0%, 32=0.0%, 64=0.0%, >=64=0.0%

issued : total=r=0/w=524288/d=0, short=r=0/w=0/d=0

latency : target=0, window=0, percentile=100.00%, depth=1

Run status group 0 (all jobs):

WRITE: io=2048.0MB, aggrb=10116KB/s, minb=10116KB/s, maxb=10116KB/s, mint=207299msec, maxt=207299msec